CHAPTER 3
AIRWORTHINESS STANDARDS
TRANSPORT CATEGORY ROTORCRAFT

MISCELLANEOUS GUIDANCE (MG)

AC 29 MG 2. STANDARDIZED TEST PROCEDURE FOR ROTORCRAFT DC ELECTRICAL SYSTEM TESTS.

a. Test Requirements.

(1) General. The following functions and characteristics are to be evaluated:

(i) Normal System Operation.

(ii) Parallel Load Division.

(iii) Excitation.

(iv) Stabilization.

(v) Systems Malfunction.

(vi) Environmental Capability.

(vii) Electromagnetic Compatibility.

(viii) Cooling Capability.

(ix) Surge Characteristics, Ripple Voltage, and Voltage Spikes.

(2) Instrumentation. Calibration records should be available for all instrumentation. Current and voltage vs. time should be recorded in a permanent form. Enough specific currents and voltages should be recorded to allow reconstruction of any sequence of events that would happen as a result of any system testing described herein.

(3) Regulatory References. Sections 29.1301, 29.1307(c), (d), (e), 29.1309, 29.1351, 29.1353, 29.1355, 29.1357, 29.1363.

(4) Miscellaneous. The assigned FAA/AUTHORITY systems and equipment engineer normally witnesses these tests and should be notified as far in advance of the testing as possible to minimize scheduling problems. Conformity of the test setup must be established prior to conducting any testing. Most of the above test categories can be conducted on a bench test setup. A bench test setup is especially recommended in the case of the system malfunction tests. It is the applicant's option to demonstrate his

equipment either on the bench or installed for ground tests. When a bench setup is used, it should represent the actual aircraft installation to the extent that components and wiring (type, gage, and length) are duplicated. Some retesting may be necessary on the aircraft to verify the bench test results.

b. Ground and Bench Test Procedures.

CAUTION: Prior to disconnecting the battery and removing or adding large loads, either isolate the avionics systems or assure that transients induced are within limits of the avionics equipment.

(1) Normal System Operation.

NOTE: Equipment should be operated for at least 10 minutes prior to each test as a warmup.

(i) Minimum electrical load for paralleling and minimum engine RPM.

(ii) Vary RPM of all engines from low to high and back to low.

(iii) Repeat b(1)(ii) for maximum and 50 percent of maximum electrical loads.

(2) Parallel Load Division (if parallel system).

(i) Minimum electrical load for paralleling and minimum engine RPM.

(ii) Fifty percent of maximum electrical load and minimum engine RPM.

(iii) Maximum electrical load and minimum engine RPM.

(iv) Minimum electrical load for paralleling, vary No. 1 engine RPM from low to high and back to low while holding the RPM of the other engine at minimum (low).

(v) Repeat b(2)(d) for each other engine on the rotorcraft.

(vi) Repeat b(2)(d) and b(2)(e) procedures with 50 percent of maximum electrical load.

(vii) Repeat b(2)(d) and b(2)(e) procedures with a maximum electrical load.

(3) Excitation.

NOTE: All of these tests are to be conducted with the battery OFF since the purpose of the tests is to determine if the ship's battery is necessary for excitation of the alternator(s)/generator(s).

(i) Minimum anticipated electrical load, low engine RPM, and alternator(s)/generator(s) OFF. Demonstrate that when an alternator/generator is turned ON, it will come on the line. Repeat for any other alternators/generators in the system.

(ii) Maximum electrical load, low engine RPM, and alternator(s)/generator(s) OFF. Demonstrate that each alternator/generator will individually come on the line.

(iii) Minimum anticipated electrical load, high engine RPM, and alternator(s)/generator(s) OFF. Demonstrate that each alternator/generator will individually come on the line.

(4) Stabilization.

NOTE: All of these tests are to be conducted with the ship's battery OFF, since the purpose of the tests is to determine if the ship's battery is necessary for stabilization of the alternator/generator. In each case, if the ship's battery is not necessary for stabilization, the alternator/generator should be on the line and remain there at a satisfactory voltage level.

(i) Minimum anticipated electrical load, low engine RPM, alternator(s)/generator(s) ON. Switch on the heaviest electrical load that is anticipated to be installed on the aircraft.

(ii) Repeat b(4)(i) for a maximum electrical load and low engine RPM.

(iii) Repeat b(4)(i) for a minimum anticipated electrical load and high engine RPM.

(iv) Repeat b(4)(i) for a maximum electrical load and high engine RPM.

(5) System Malfunctions.

(i) Overcurrent faults (faults to airframe ground that are less than 5.0 Milliohms) should be applied to buses and feeders as necessary to demonstrate that the system's overcurrent circuit protective devices are properly coordinated and provide adequate protection/fault isolation.

(ii) Simulate an overvoltage condition on each alternator/generator to demonstrate satisfactory operation of the overvoltage sensing network. On a

multiengine configuration, the faulty alternator/generator should be removed without affecting operation of the remainder of the system.

(iii) The annunciation circuitry should be checked for indication of failures such as overvoltage, tripped generators, overcurrent, open feeders, open tie breakers, etc.

(6) Aircraft Ground Tests. If the above tests (reference b(1) through (4) inclusive) are conducted on a bench setup, enough tests should be repeated on the aircraft to validate the bench test results. The following tests should be conducted on the aircraft:

(i) Normal Battery Starts. Start all engines on the aircraft following the normal procedure prescribed in the flight manual. Record starter volts and amperes, time, and any other parameters deemed necessary.

(ii) Ground Power Cart Starts. If the aircraft is equipped with a plug for a ground power cart, use the procedure described in the flight manual and start all engines. Record starter volts and amperes, time, and any other parameters deemed necessary.

(iii) Emergency Battery Operation (if provided). The emergency battery mode of operation should be tested to assure at least proper switching, annunciation, and battery capacity. In some instances, an analysis of battery capacity may be adequate.

(iv) Other Tests. Conduct other tests as necessary to demonstrate proper operation of the specific design being evaluated.

(v) Distribution System Tests. With all systems operating individually, open and close feeder circuit breakers and system circuit breakers and assure separation of power sources for essential systems. For example, removing power from one bus by opening a feeder should not result in loss of both NAV 1 and NAV 2 or both COMM 1 and COMM 2 or both attitude gyros, or for example, opening NAV 1 circuit breaker should not affect NAV 2, etc. If the opening of the feeder protection has been satisfactorily demonstrated on a bench test facility, it should not be necessary to repeat that demonstration on the actual aircraft. The effect of loss of power sources should also be demonstrated on the aircraft. Reference §§ 29.1357(e) and 29.1309.

(7) Environmental Qualification. Each component of the system, such as relays, switches, alternator, generator, sensor, regulator, diode, etc., should be qualified to the critical environmental parameters. The temperature, altitude, humidity, and vibration expected in the approved aircraft operational envelope should fall within those limits the applicant substantiates for the electrical system components. (Refer to paragraph AC 29.1309.)

(8) Electromagnetic Compatibility. At no time during any of the qualification testing described herein should objectionable interference in the aircraft's radio, navigation, cockpit instrument, autopilot, or interphone system be considered acceptable.

NOTE: The quantitative type testing used for Items (7) and (8) above is outside the scope of this document. The latest revision of RTCA Document DO-160 is an acceptable standard.

(9) Transient Tests. The D.C. system should be tested and shown to exhibit surge, ripple, and spike voltages within the limits of the latest revision of RTCA Document DO-160.

(i) The surge and ripple voltage tolerance of avionic equipment is defined by the latest revision of RTCA Document DO-160. Category Z is considered applicable to rotorcraft D.C. systems.

(ii) The voltage spike tolerance of avionic equipment is defined by the latest revision of RTCA Document DO-160.

(10) Ground and Bench Test Report. At the conclusion of the ground and bench test program a report should be prepared and submitted that contains at least the following:

(i) System schematic (including instrumentation tie-in).

(ii) Instrumentation list (including calibration records).

(iii) Test result recordings.

(iv) Detailed procedures and results obtained.

(v) Conformity inspection records.

(vi) Other data, photographs, etc., to describe the test setup.

(vii) Summary of the test results. This summary should show the maximum load to which each bus, alternator/generator, etc., has been tested.

(viii) Analysis of test results. This should describe how compliance with the regulations has been shown. It should include consideration of the critical failure modes. Refer to paragraphs AC 29 MG 1 a(4)(ii) and AC 29.1309c for further information on failure analyses.

c. Flight Test Procedures.

(1) Alternator/generator cooling tests should be conducted in accordance with paragraph AC 29.1351.

(2) On multiengine rotorcraft, single-engine air starts should be conducted using the manufacturer's recommended procedures. This should be accomplished for each engine individually.

(3) A cockpit evaluation of the electrical system should be conducted to evaluate:

(i) Switch, circuit breaker, and annunciator identification.

(ii) Visibility of placarding, switches, etc., during bright sunlight and night operation.

(iii) Color of annunciators as related to the function/malfunction annunciated.

(iv) Load meter readability.

(v) Access to essential switches, circuit breakers, etc.

(vi) Electromagnetic interference.

(vii) Compatibility of the electrical system with the rotorcraft flight manual and the need for additional procedures in the RFM.

(viii) Clarity of functions such as opened feeder breakers, tie breakers, related annunciation, and necessary corrective action in the event of malfunction.

(ix) Absence of undesired functions in relation to switch combinations.